Fishery Data Series No. 95-36

Movements of Radio-Tagged Arctic Grayling in the Tok River Drainage

by

William P. Ridder

November 1995

Alaska Department of Fish and Game

Division of Sport Fish

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used in Division of Sport Fish Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications without definition. All others must be defined in the text at first mention, as well as in the titles or footnotes of tables and in figures or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

FISHERY DATA SERIES NO. 95-36

MOVEMENTS OF RADIO-TAGGED ARCTIC GRAYLING IN THE TOK RIVER DRAINAGE

by

William P. Ridder
Division of Sport Fish, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

November 1995

Development and publication of this manuscript were partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-10, Job No. R-3-2(a).

The Fishery Data Series was established in 1987 for the publication of technically oriented results for a single project or a group of closely related projects. Fishery Data Series reports are intended for fishery and other technical professionals. Distribution is to state and local publication distribution centers, libraries and individuals and, on request, to other libraries, agencies, and individuals. This publication has undergone editorial and peer review.

William P. Ridder
Alaska Department of Fish and Game, Division of Sport Fish, Region III,
1300 College Road, Fairbanks, AK 99701-1599, USA

This document should be cited as:
Ridder, W. P. 1995. Movements of radio-tagged Arctic grayling in the Tok River drainage. Alaska Department of Fish and Game, Fishery Data Series No. 95-36, Anchorage.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

ABSTRACT

Radio telemetry was used to determine overwintering, spawning, and summer feeding areas of adult Arctic grayling *Thymallus arcticus* in the Tok River drainage, a second order tributary of the upper Tanana River drainage of interior Alaska. In late September 1994, 25 adult Arctic grayling were implanted with radio transmitters. The fish were tracked from aircraft seven times from January to August 1995. By April, the fish had moved downstream 2 to 15 miles from the release site to four overwintering areas in the Little Tok and Tok rivers with the majority being found at the mouth of the Little Tok River. Spawning areas appeared to be restricted to the Station Creek drainage, a tributary of the Little Tok River. Distances traveled between overwintering areas and likely spawning areas ranged from 17 to 26 miles. After spawning, fish were dispersed along Station Creek and 28 miles of the lower Little Tok River. By August, fish had vacated Station Creek with the majority residing downstream in the Little Tok River.

Key words: Arctic grayling, *Thymallus arcticus*, radio telemetry, overwintering, spawning, feeding areas, seasonal movements, interior Alaska, Tok River drainage.

INTRODUCTION

Road accessible fisheries for Arctic grayling *Thymallus arcticus* (hereafter referred to as grayling) in the vicinity of Tok, a community of 1,300 located in the upper Tanana River drainage at the junction of the Alaskan and Glenn (Tok Cutoff) highways, are sparse and small in size (Figure 1). These fisheries are concentrated at five sites along a 13 mi stretch of highway within the Tok River drainage, 19 mi south of Tok, and include the Tok River, Tok Overflow, Tok Overflow #2, Little Tok River, and Mineral Lake (Figure 2). The estimated average yearly harvest is 875 grayling, of which 65% comes from the Little Tok River (Table 1). These fisheries are either highly seasonal or subject to disruption from glacial, spring, and storm runoff events.

Since 1987, local residents have expressed concern over an apparent decline in numbers and size composition of the spring grayling fisheries at two of the above areas. Initially, their concern centered on the spring fishery at the outlet of Mineral Lake (hereafter referred to as Mineral Lake Outlet). This fishery targets a spawning population in the Tok River drainage which helped persuade the Alaska Board of Fisheries to include Mineral Lake Outlet in the 1988 special regulations for grayling in the Tanana River drainage[1]. More recently, local concern became focused on the fishery at the Tok Overflow, a small spring-fed tributary to the Tok River 13 mi by highway below Mineral Lake Outlet.

Prior to this study, grayling spawning and overwintering areas in the Tok River drainage were ill-defined. Identification of these areas was desirable for several reasons. Studies by Ridder (1989) and Fleming and Ridder (1991) found that grayling spawning in Mineral Lake Outlet matured at younger ages than other grayling spawning stocks in the middle Tanana River drainage. Younger age at maturity suggests overexploitation. However, because spawning areas in the Tok River drainage were ill-defined, it was not possible to determine if spawners at Mineral Lake Outlet were representative of the entire spawning population in the Tok River drainage. Similarly, it was unknown if grayling density in one overwintering area of the middle Tok River (135 fish per mile)

[1] These regulations included limiting the fishery to catch and release till the first Saturday in June, a 305 mm total length limit, and a no bait restriction. In 1992, the Board accepted local requests for some consumptive use and relaxed the regulations to a two fish daily bag and possession limit with no season or size restrictions while retaining the no bait restriction.

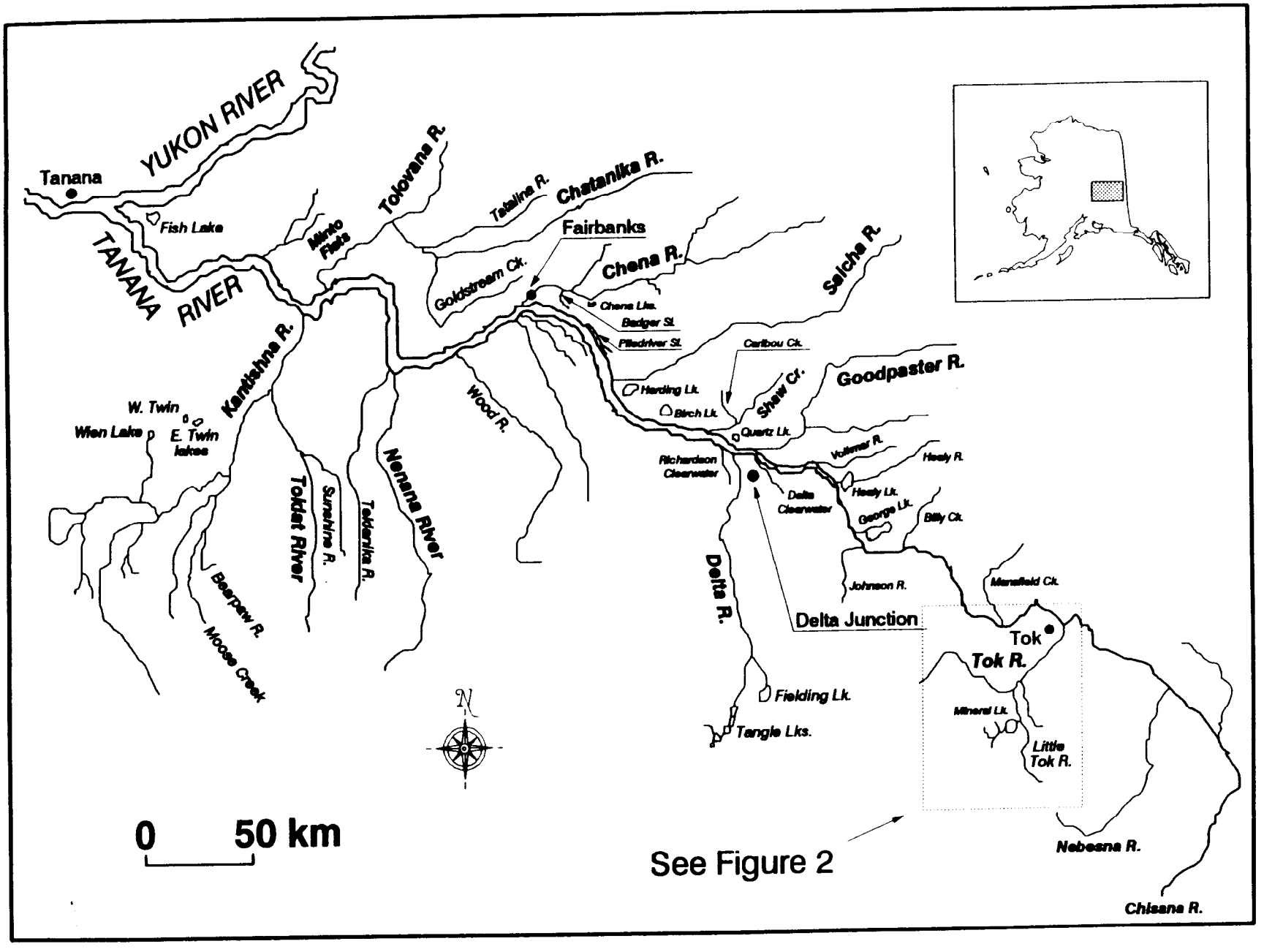

Figure 1.-The Tanana River drainage.

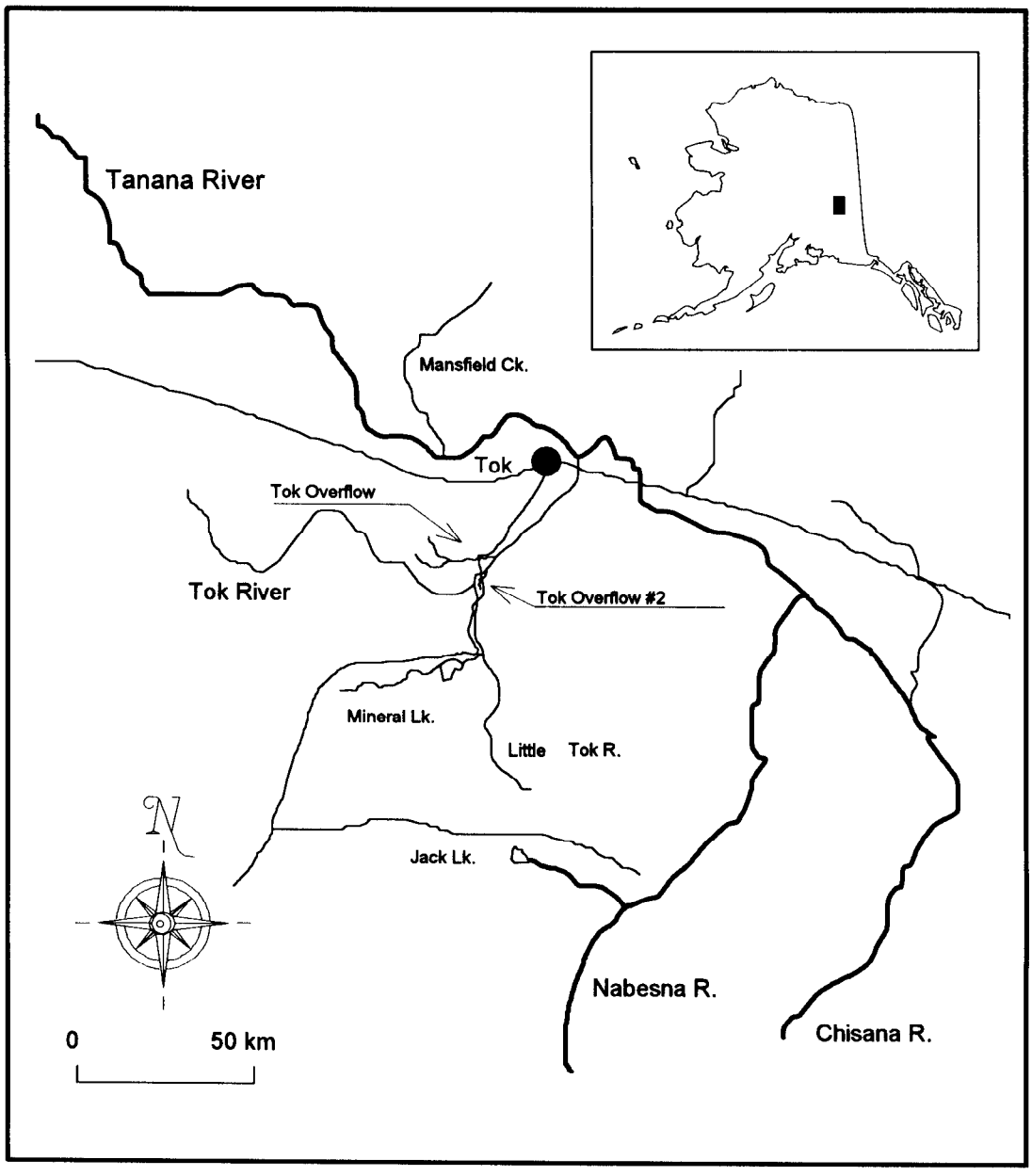

Figure 2.-The Tok River drainage.

Table 1.-Recreational grayling harvests and angling effort in the Tok and Little Tok River drainages, 1983-1994.

	Little Tok River[a]		Mineral Lake[a]		Tok Overflow[a]		Tok River[a]	
Year	Harvest	Effort	Harvest	Effort	Harvest	Effort	Harvest	Effort
1983	976	877	0	202	441	455	357	320
1984	1,025	488	0	436	156	105	117	87
1985	---	---	69	451	---	---	---	---
1986	1,407	443	---	---	---	---	559	153
1987	66	67	---	---	79	163	---	---
1988[a]	473	655	18	93	55	62	0	93
1989[a]	---	---	0	65	0	133	200	100
1990[a]	253	725	84	595	17	78	51	401
1991[a]	710	906	49	213	73	27	0	186
1992	0	75	45	245	---	---	113	160
1993[e]	---	---	---	---	---	---	---	---
1994[e]	243	391	32	874	102	36	0	150
Average	572	514	33	353	115	132	155	183

[a] Unpublished harvest and effort statistics from the Statewide Harvest Survey (Mills, personal communication).

[b] Harvest is the estimated number of grayling taken.

[c] Effort is the number of angler-days expended for all species of fish.

[d] Special regulations were in effect on the outlet of Mineral Lake in 1988 through 1991: 1. Catch and release grayling fishing from 1 April to the first Saturday in June with a 5 fish daily bag and possession limit for the open season; 2. 12 inch (305 mm) minimum length limit; and, 3. artificial lures or flies only. The remainder of the drainage had no closed season, no gear restrictions, and, a 5 fish daily bag and possession limit.

[e] Special regulations were in effect on the outlet of Mineral Lake in 1992 through 1994: 1. Two fish daily bag and possession limit; and, 2. artificial lures or flies only. The remainder of the drainage had no closed season, no gear restrictions, and, a 5 fish daily bag and possession limit.

as determined by Ridder (1994) represented grayling density for the entire overwintering population or not.

Considering the small localized fisheries, and local perceptions of depressed fisheries, information on the distribution of grayling within the Tok River drainage was needed to design studies that would better assess population status and options for management. Accordingly, the research objective of the current study was to locate the spawning and overwintering areas of grayling in the Tok River drainage using radio telemetry.

STUDY AREA

The Little Tok River originates in the Mentasta Mountains and flows over 50 mi to its confluence with the Tok River approximately 8 mi above the mouth of the Tok Overflow and 15 mi below Mineral Lake Outlet. The river is a rapid runoff stream marginally affected by glaciers and is slightly turbid and fishable at low summer flows. The river becomes high and turbid after heavy or persistent rains, which make it unfishable. Road access is available at three locations: the Glenn Highway crossing at river mile 4; a short side road off the old Glenn Highway just above the highway crossing; and, at the old Glenn Highway bridge (locally known as "Broken Bridge") at river mile 15 (immediately downstream of the mouth of Mineral Lake Outlet). Dikes, side roads and the adjacent Glenn Highway in the Broken Bridge area allow direct access to approximately a 3 mi reach of the river. The morphology of the river at the upstream access is distinctly different than at the downstream access points. At Broken Bridge, the river is 40 ft wide and composed primarily of swift 3+ ft deep runs over gravel and small cobble. Pools are deep (7 ft) and generally located on the outside of bends and along cut banks. Riffles are short, swift, and generally less than 2 ft deep. The river here is also moderately to heavily fouled with fallen trees, logs and brush which makes navigation and angling difficult. At the downstream access sites, flow diminishes, the river deepens, and riffles and runs are nearly non-existent. Debris is less prevalent making navigation possible. However, angling from shore remains difficult due to dense riparian vegetation and steep, high banks. Sampling the Little Tok River in 1994 occurred at two locations: from the mouth to approximately 7 mi upstream, and in the Broken Bridge area from the Mineral Lake Outlet confluence to a point approximately 2 mi downstream .

METHODS

Radio telemetry was used to track 25 grayling that were surgically implanted with radio transmitters each of which had a unique frequency (Appendix A, Table 2). The radio transmitters were manufactured by Lotek Engineering Inc (Model FSM-5) and were 45 mm long and 11 mm in diameter, had an air weight of 7.2 g, and an antenna 31 mm long. Following the 2% rule (transmitter weight not to exceed 2% of the fish's weight in air, Winter 1983), no fish weighing less than 360 g were selected for implanting. Grayling were captured by hook and line gear between 26 September and 4 October 1994 in the lower 15 mi of the Little Tok River.

Fish were anesthetized with MS-222 and transmitters placed in the coelomic cavity following the surgical procedures described by West et al. (1992). An exception was that 3-4 stitches were used to close the 20-30 mm long incisions and these were followed by an application of "Vetbond", a cyanoacrylate tissue adhesive. Surgery times averaged 6 min. After surgery, each

Table 2.-Summary of tracking success for 25 radio tagged grayling during seven flights. (Yes = tag located; No = tag not located; NT = tag not tracked because fish was suspected of being dead; Arrows = movement since last location: ↔ = no movement, ↑ = upstream, ↓ = downstream).

ID#[a]	12-Jan	16-Mar	18-Apr	17-May	25-May	19-Jun	7-Aug
1	Yes↓	Yes↑	Yes↓	Yes↑	**No**	Yes↓	Yes↓
2	Yes↓	Yes↓	Yes↑	Yes↓	**NT**	Yes↔[c]	**Dead**
3	Yes↓	Yes↔	Yes↔	Yes↑	Yes↓	Yes↓	**No**
4	Yes↓	Yes↔	Yes↔	Yes↑	Yes↑	Yes↓↑[b]	Yes↓
5	Yes↓	Yes↔	Yes↔	Yes↑	Yes↔	Yes↓	Yes↔
6	Yes↓	Yes↔	Yes↔	Yes↑	Yes↓	Yes↓	Yes↔
7	Yes↓	Yes↔	Yes↔	Yes↑	Yes↔	Yes↓	Yes↔
8	Yes↓	Yes↔	Yes↑	Yes↑	**No**	Yes↓	**No**
9	Yes↓	Yes↔	Yes↔	Yes↑	Yes↔	Yes↓	Yes↔
10	Yes↓	Yes↔	Yes↔	Yes↔	**NT**	Yes↔[c]	**Dead**
11	Yes↓	Yes↔	Yes↔	Yes↑	Yes↑	Yes↓	Yes↓
12	Yes↓	Yes↔	Yes↔	Yes↑	Yes↔	Yes↔	**Dead**
13	Yes↓	Yes↔	Yes↔	Yes↑	Yes↔	Yes↓	Yes↔
14	**No**	**No**	Yes↓	Yes↑	Yes↔	Yes↔	**Dead**
15	Yes↓	Yes↔	Yes↑	Yes↓	**NT**	Yes↔[c]	**Dead**
16	Yes↓	Yes↔	Yes↔	**No**	Yes↑	Yes↓↑[b]	**No**
17	Yes↓	Yes↔	Yes↔	Yes↔	**NT**	**No**	**Dead**
18	Yes↓	Yes↔	Yes↔	Yes↑	Yes↓	Yes↓	Yes↔
20	Yes↓	Yes↔	Yes↔	Yes↑	Yes↔	Yes↔	**Dead**
21	Yes↓	Yes↔	Yes↔	Yes↑	Yes↔	Yes↓↑[b]	Yes↔
22	Yes↓	Yes↔	Yes↔	Yes↑	Yes↔	Yes↓	Yes↔
23	Yes↓	**No**	**No**	**No**	**NT**	**NT**[d]	**NT**[d]
24	**No**	Yes↓	Yes↔	**No**	Yes↑	**No**	Yes↓↑[b]
25	Yes↓	Yes↔	Yes↔	Yes↑	**No**	Yes↔	**Dead**
26	Yes↓	Yes↔	Yes↔	Yes↑	Yes↓	Yes↓	Yes↔

[a] Numbering skips fish 19 and goes to fish number 26, however there were a total of 25 fish in the study.

[b] Fish moved downstream out of Station Creek and then upstream in the Little Tok River.

[c] Lack of movement verified fish was dead.

[d] Transmitter failed.

fish was allowed to fully recover from the anesthetic in a tub of fresh water prior to release. No mortalities occurred during surgery or the recovery period.

Location of tagged grayling was monitored seven times from January through August 1995 from a Piper PA-18 equipped with a Telonics TR-2 receiver coupled with a TS-1 scanner and an 'H' antennae mounted on each wing strut. Flights were directly over stream courses as much as practical at 300-500 ft above ground level and proceeded upstream at 70 mi/h. With the exception of the January tracking flight, all tracking flights began 2 mi below Clearwater Creek on the Tok River and proceeded upstream, covering the drainage of the Tok Overflow, to the Little Tok River. They then proceeded up the Little Tok River to the Station Creek drainage. After completing the two passes of Station Creek, flights continued up the Little Tok to its head before covering the Little Tok's three major tributaries. The 10 mi reach of the Tok River above the Little Tok was surveyed only during the April and June flights. The January monitoring flight began at the village of Tanacross on the Tanana River and proceeded upstream to a point 1 mi past the mouth of the Tok River. From there, the flight continued up the Tok River to cover the aforementioned drainages. The January survey of the Tanana and Tok Rivers was not repeated since the Tok River dries up below Clearwater Creek in midwinter (Ridder 1994) and was glacial for the May through August period.

Location of a transmitter was determined by monitoring its pulse intensity and was recorded with a GPS (global positioning system) receiver as latitude and longitude coordinates. In some instances, two or more passes along a stream reach were necessary to determine the location of a specific transmitter. In a few instances, pulse intensity was erratic and dependent on the direction of the flight; thus, determination of location was somewhat of a guess. The coordinates for each transmitter were then plotted on United States Geological Survey topographical maps (1:63,360 scale). Distances were approximated with the use of a planimeter on 1:63,000 USGS maps. As with determining the location, the coordinates were judged to be less than precise as some plots showed fish up to a quarter of a mile off the stream. Movements of fish between trackings were said to have occurred if plotted locations were greater than one quarter mile apart. Transmitter locations are presented in figures as generalizations of these plots. The locations are shown as falling within an approximate 1 mi reach of stream.

Determinations of mortality are necessary in qualifying the tracking results. This study addressed mortality as inferences from tracking results. If fish did not move between two or more trackings and these trackings spanned times of movement, then the fish was likely dead. Also, if a fish was found in progressively downstream locations when upstream movement was the norm, then it was presumed dead.

All captured grayling were measured to the nearest 1 mm fork length (FL). Those fish selected for surgery were weighed to the nearest gram and, for age determination two scales were taken from an area located approximately six scale rows above the lateral line just posterior to the insertion of the dorsal fin. The scales were later cleaned and mounted on a gum card. The gum card was used to make impressions of the scales on triacetate film (30 sec at 137,895 kPa, at a temperature of 97°C). Ages were determined in a single reading using a microfiche reader according to criteria outlined by Yole (1975).

All data pertaining to age, length, sex, tag numbers, colors, and losses (from previous studies), capture location, and finclips were recorded on mark sense forms and transformed into an

electronic (ASCII) data file. This data file, U2160LA4.dta, is archived at the Alaska Department of Fish and Game, Division of Sport Fish, Research and Technical Services, 333 Raspberry Road, Anchorage, Alaska 99518-1599.

Sex was determined by sexual dimorphism. Dimorphism is evident in differences in length of the dorsal fin (in fish greater than 300 mm FL, the male dorsal fin usually extends to the adipose fin whereas the female dorsal fin is noticeably shorter; Wojcik 1955).

RESULTS

From 26 September through 4 October 1994, 45 angler-hours of effort were expended to capture 62 grayling in the Little Tok River (Appendix B). Of these 62 fish, 25 were selected for surgery. Radio tagged fish ranged from 319 to 413 mm FL and from 367 to 780 g, and were taken from two 2 mi areas: river miles 2-4 and 5-7 (Appendix A). Nineteen of these fish were collected along river miles 5-7 and were released at the bridge at river mile 4. The remaining six fish were collected along river miles 2-4 and were released at river mile 2. Two of the radio tagged fish were recaptures from Mineral Lake Outlet (fish #12 and #18). No fish were captured in the Broken Bridge area that met the minimum weight requirements for implanting (360 g, approximately 310 mm FL).

OVERWINTERING

Three flights were conducted over winter and early spring. All 25 fish were located at least once during the flights. Twenty-two fish were located all three times; one fish (#24) was located twice; and, two fish (#'s 14 and 23) were only located once (Table 2).

Four overwintering areas were determined: one area was located within a 2 mi reach upstream of the mouth of the Little Tok River; and three areas were located in the Tok River. No radio tagged fish overwintered in the Tok Overflow or in the 3 mi reach of open water in the Tok River immediately below the Tok Overflow. In January, 23 fish (two fish, #14 and #24 were not located) had moved as much as 18 mi downstream from release sites to three areas (Figure 3). The largest concentration, 18 fish, was found in a 2 mi reach above the mouth of the Little Tok River. Three fish were located along a quarter mile reach of the Tok River above the highway bridge and two fish were found in a quarter mile reach above Clearwater Creek. By April, fish had concentrated into a half mile reach from the mouth (Figures 4 and 5). A fourth overwintering area 4 mi below Clearwater Creek was indicated by the location of fish #14; this fish had not been located in the first two flights. The April flight indicated an upstream movement by three fish (#2 #8, and #15) from the Tok River area to the mouth of the Little Tok River (Figures 4 and 5).

SPAWNING

It is likely that spawning occurred in two different areas: Station Creek and Mineral Lake. Twenty-four of the 25 fish were found at least once during the two flights flown during the May spawning period (Table 2); however, only the locations of 20 fish were considered valid for determination of spawning areas. Four fish (#'s 2, 10, 15, and 17) were not tracked on the second flight because they were suspected as being dead. This suspicion was based on the fact that they either had not moved or were located further downstream in three of the four flights

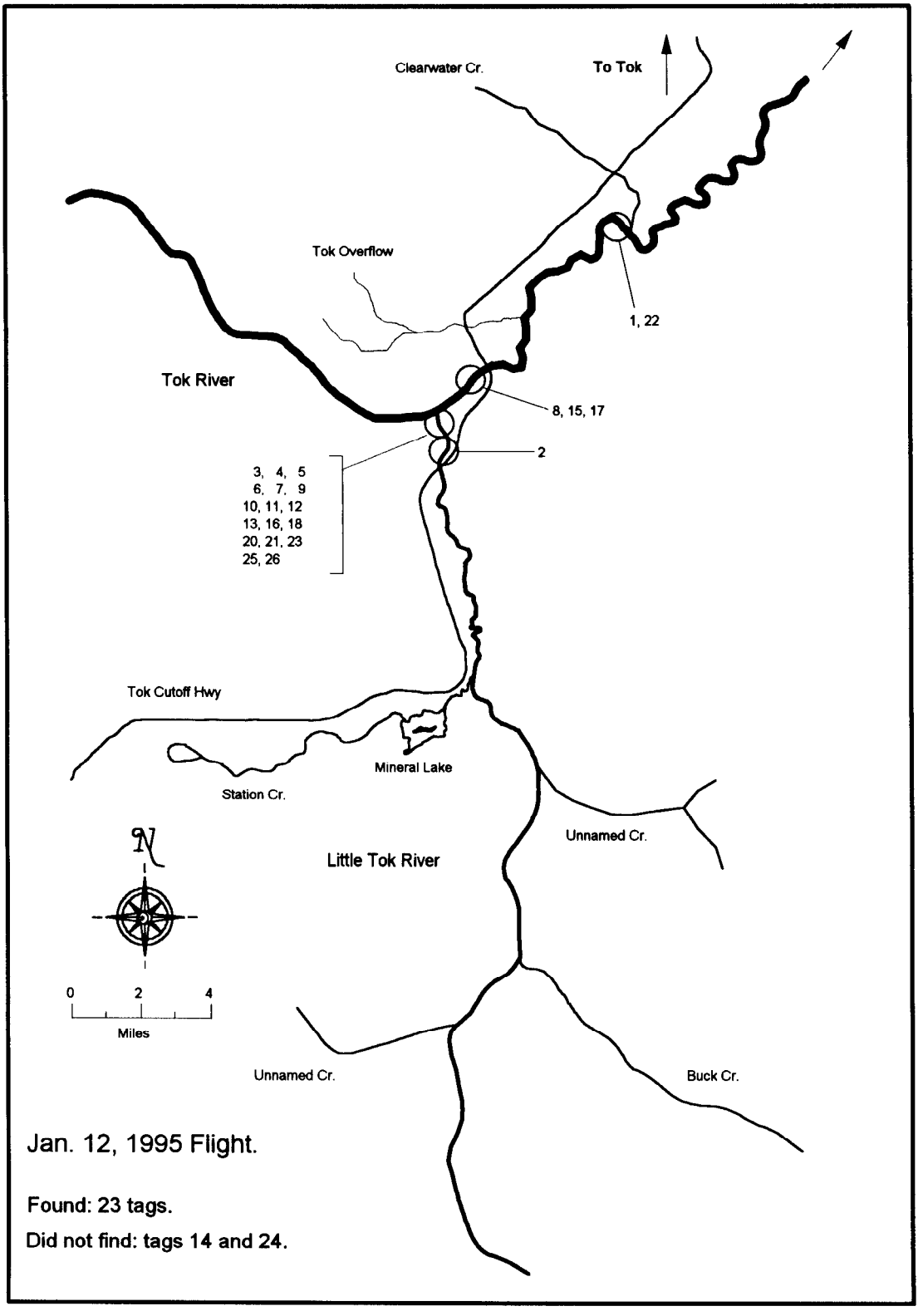

Figure 3.-Locations of radio-tagged grayling in the Tok River drainage on 12 January 1995.

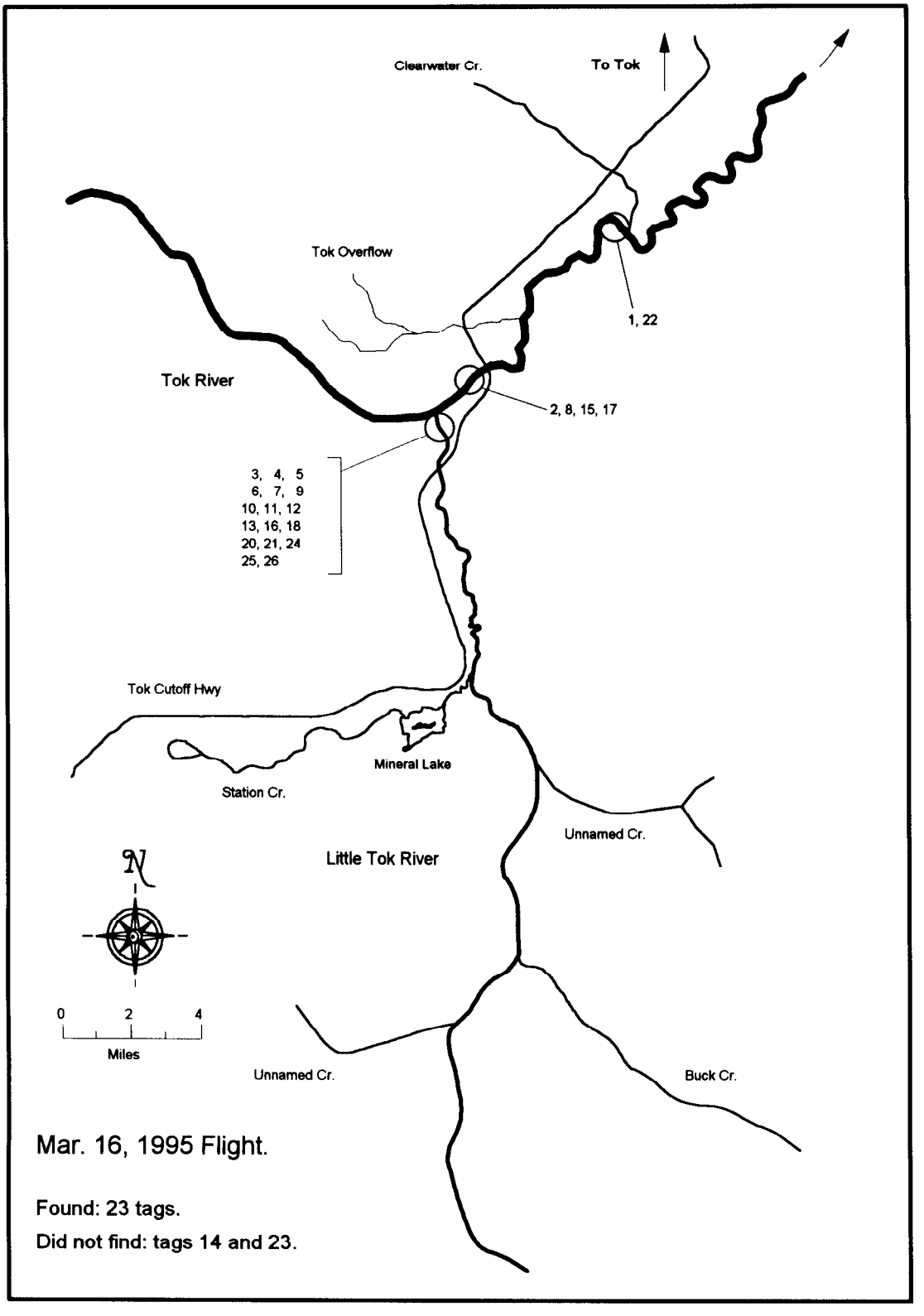

Figure 4.-Locations of radio-tagged grayling in the Tok River drainage on 16 March 1995.

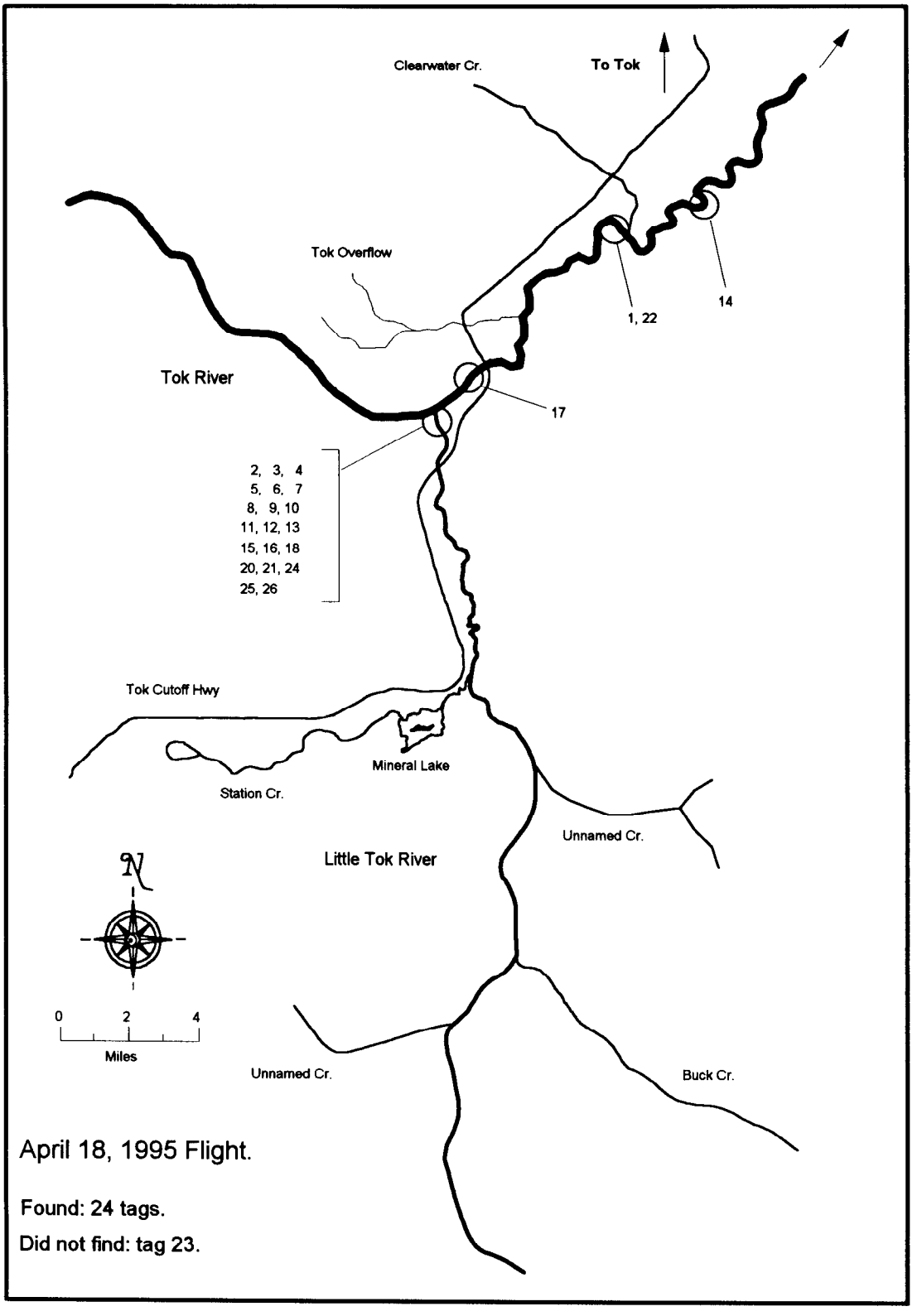

Figure 5.-Locations of radio-tagged grayling in the Tok River drainage on 18 April 1995.

(Figures 3 through 6). A fifth fish (#23) was not tracked because the transmitter likely failed - it had not been relocated since the first flight. Of the 20 fish assumed alive and with working tags, 18 fish were located at least once within ten one-quarter mile reaches of the Station Creek drainage. The majority of sightings (n =5) during each May flight occurred in the southwest portion of Mineral Lake. Two fish, #14 and #20, were located twice at the same locations in the Little Tok River (Figures 6 and 7). Subsequent flights in June and August placed them in the same locations and suggested that they were dead. Whether they were dead or spawning during the May flights is unknown. While grayling will spawn in a variety of habitats, the available habitat for spawning in this portion of the Little Tok River appears poor.

Of the 18 fish in Station Creek, 13 fish were located twice over the eight day period: six fish in five locations did not move, two fish moved upstream more than a mile and five fish moved downstream more than a mile. Of the 13 fish, five individual fish were found once in Mineral Lake Outlet, the one known spawning area in the Tok River drainage, with two "sightings" during the first flight and three during the second. The former fish had moved upstream into the lake and Station Creek by the second flight while the latter fish had moved downstream from the lake into the outlet area. Water temperatures in Station Creek and Mineral Lake Outlet on 19 May were 9.5°C and 10.5°C, respectively, (Appendix C), which were warmer than the mainstems of the Tok and Little Tok rivers.

SUMMER FEEDING

On 19 June, 24 of the 25 fish were tracked and 22 fish were located (Table 2, Figure 8). Four of these fish (#'s 2, 10, 15, and 17) were suspected of being dead and their lack of movement verified this suspicion. Five fish were in Station Creek, 12 fish were in the Little Tok River below Station Creek, three fish were in the Little Tok above Station Creek and, two fish were in the Tok River. Mortality of an additional four fish was indicated by non-movement since 17 May: fish #14 and #20 in the lower Little Tok River and fish #12 and #25 in Station Creek.

By late summer (7 August) 14 fish were tracked to three feeding areas: 11 fish were in the Little Tok River below Station Creek, one remained in Station Creek and had not moved since the June flight and, two fish were in the Little Tok above Station Creek (Figure 9). Of these latter two fish, one had not moved since June and one, fish #24, was a fish not found since the 25 May flight. The six fish not found were likely the result of failed tags as the flight was well beyond the tags' advertised lifespan.

DISCUSSION

The required size for radio tag implantation excluded smaller, adult grayling. While the minimum length of a fish for radio tagging was 319 mm, Clark (1992) found that 99% of grayling sampled during spawning at Mineral Lake Outlet were mature at 276 mm. Larger grayling have been found to displace smaller grayling to less favorable sites within spawning areas (Beauchamp 1990), however, it is unknown whether the selection of spawning areas differs among sizes of adult grayling. If there is no differential selection, then results from this study may be used to draw inferences about all sizes of adult grayling in the Tok River drainage.

While four overwintering areas were detected, no fish were tracked to the open water reach of the Tok River below the Tok Overflow. This open water reach has been suspected as being an overwintering site, based on the finding of small (<240 mm) grayling there in April 1993. Either

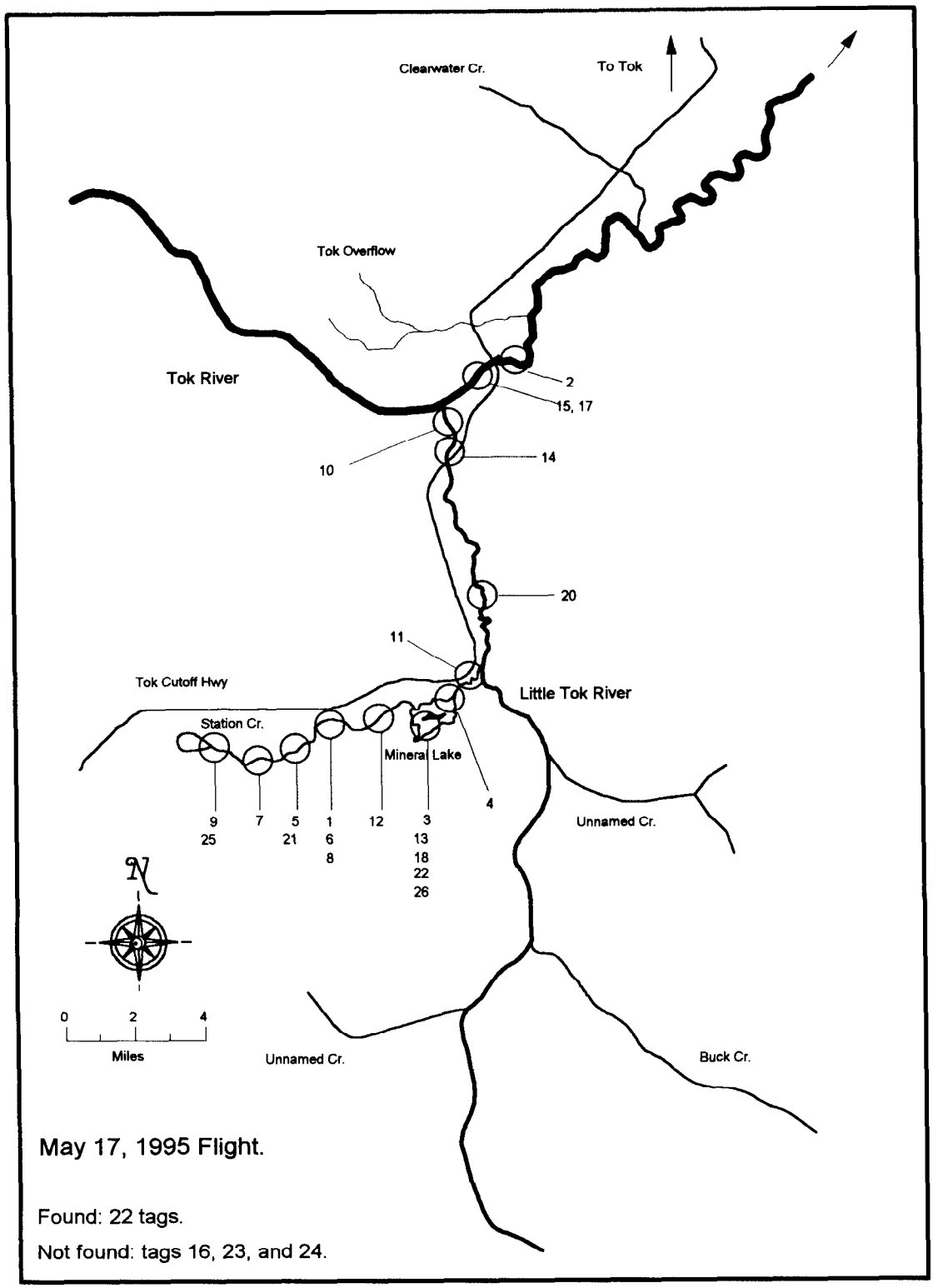

Figure 6.-Locations of radio-tagged grayling in the Tok River drainage on 17 May 1995.

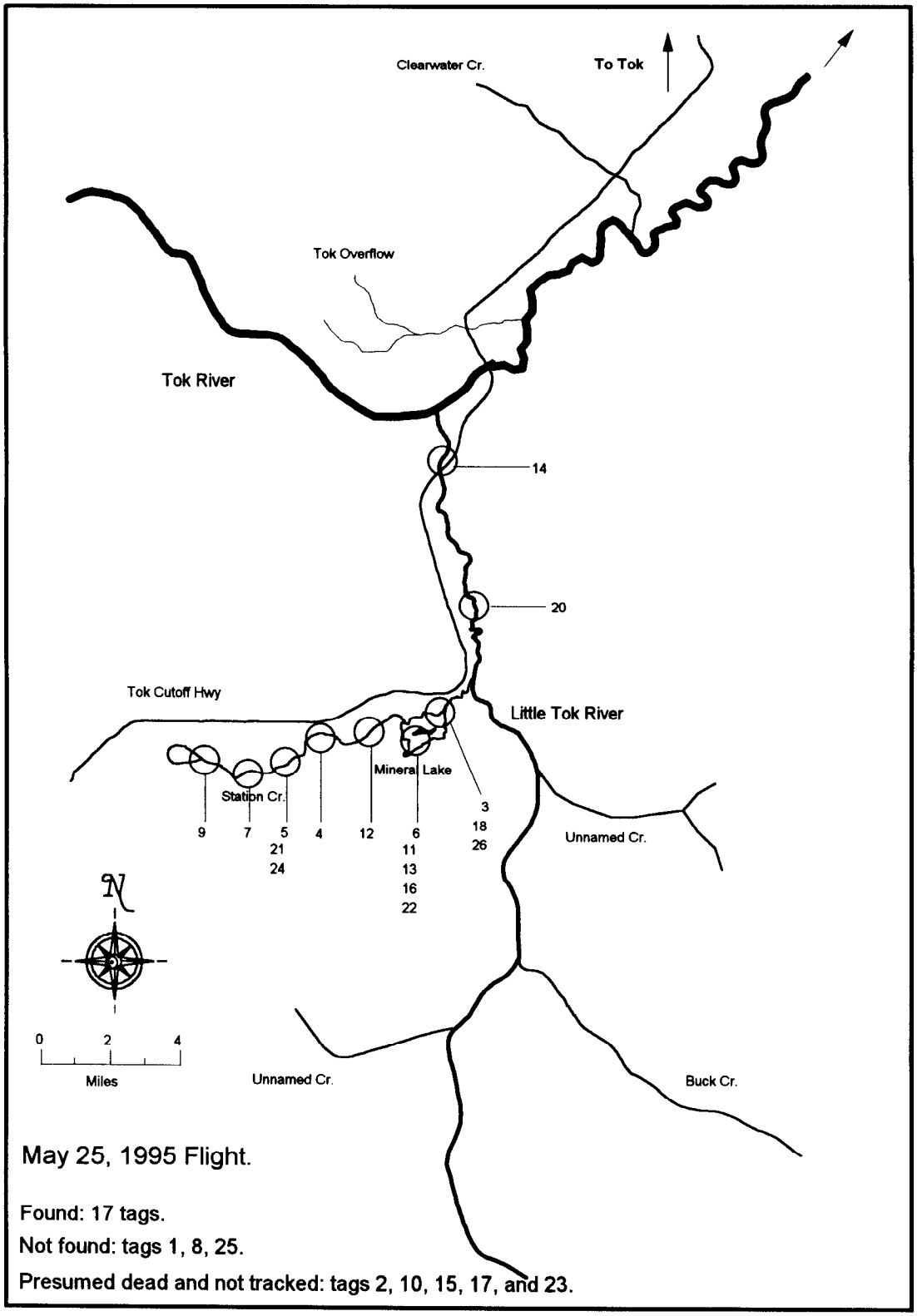

Figure 7.-Locations of radio-tagged grayling in the Tok River drainage on 25 May 1995.

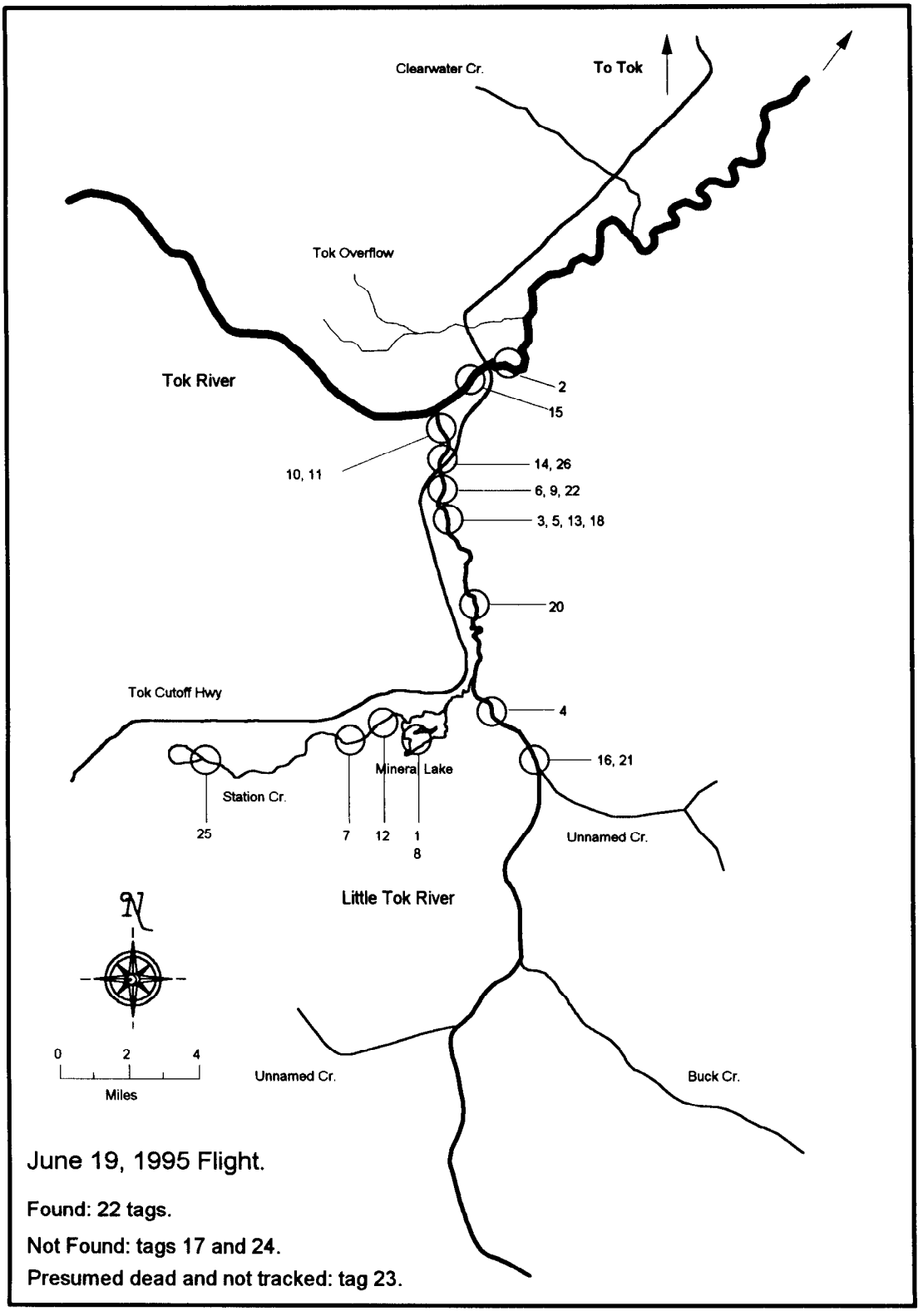

Figure 8.-Locations of radio-tagged grayling in the Tok River drainage on 19 June 1995.

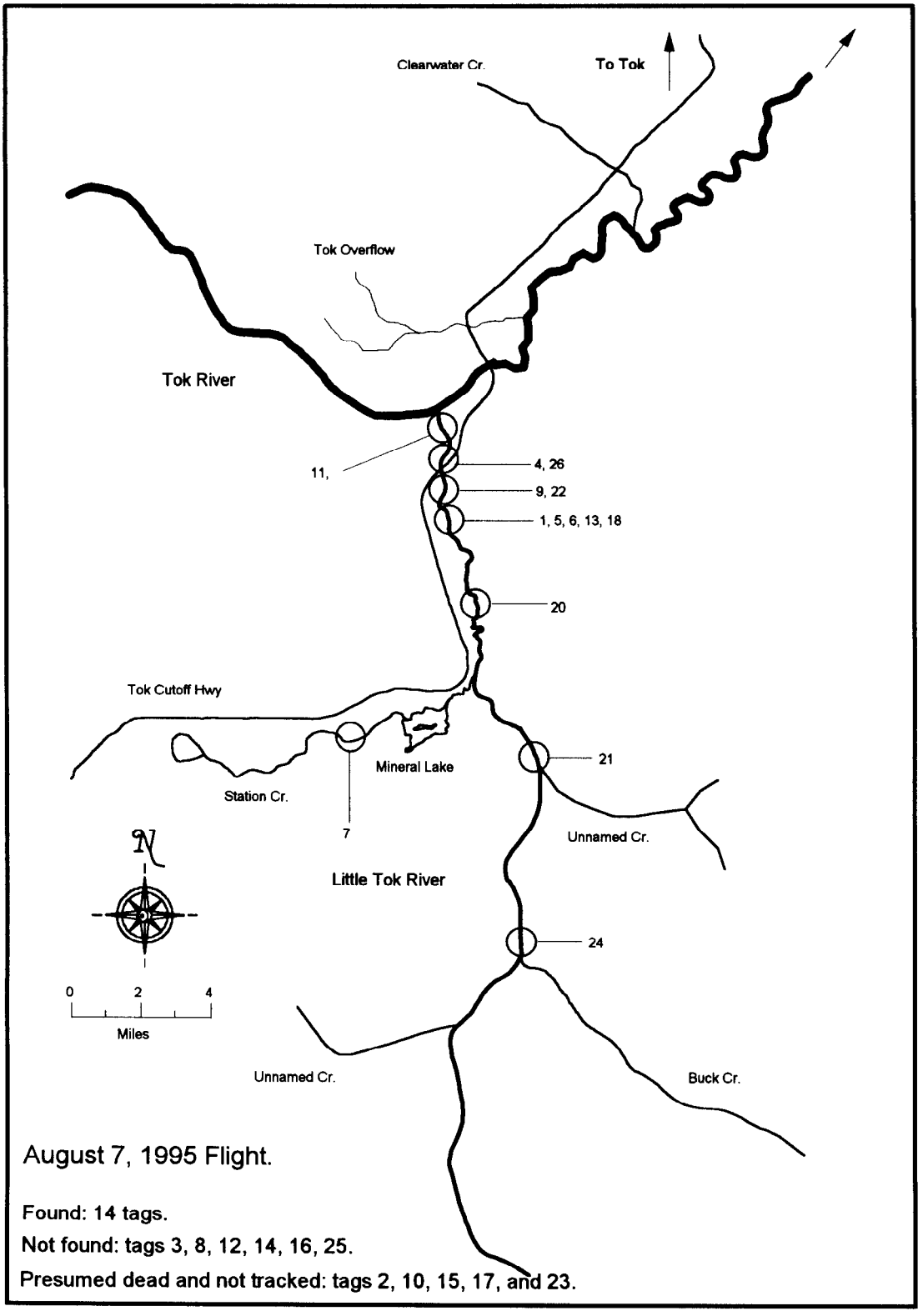

Figure 9.-Locations of radio-tagged grayling in the Tok River drainage on 7 August 1995.

the open water reach is in fact not an overwintering site, the sample size of 25 fish was insufficient to detect the reach as an overwintering area, or, the selection of overwintering areas differs among size classes of grayling, with larger fish preferring ice cover. This study cannot resolve these questions.

The fact that radio tagged fish were captured from relatively discrete areas over a short time frame may have biased the results. Grayling are a schooling fish that have been observed to remain in homogeneous groups at summer feeding areas over many years. Clark (1993) found in a five year study of intrastream movements that over 90% of tag recoveries were made within a mile of their release sites. While the homogeniety of groups of fish at overwintering and spawning areas has not been assessed, results from this study may reflect the movements of a particular group(s) of grayling rather than the entire population. This concern could have been addressed by distributing sampling over a longer time frame and wider area.

Because the May flights encompassed only the tail end of the spawning period, it cannot be stated with certainty that Station Creek is a spawning area. However, the warmer water temperatures detected at Station Creek support radio telemetry information in defining the creek as a spawning area. While there remain doubts regarding specific sites in upper Station Creek, the creek drainage itself is likely the prime spawning area in the Little Tok River drainage. Many authors have noted that grayling tend to spawning in those areas where spring water temperatures are the warmest (Beauchamp 1990, Northcote 1995). Temperature data presented here and in Ridder (1994) confirm that the Station Creek drainage is warmer than the mainstem Little Tok in the spring and summer. It is also likely warmer than the upstream tributaries. The choice of warm water spawning areas allows grayling not only to spawn early but also provides a growth and survival advantage for the young of the year over those from cold water areas. The identification of the Station Creek drainage as a primary spawning area, in addition to the previously known spawning location at Mineral Lake Outlet, should assist in designing future stock assessment studies of grayling in the Tok River drainage.

During summer, fish widely dispersed from their overwintering locations. Because the radio tags were beginning to fail by summer, the small number of working tags remaining likely precluded detection of all possible feeding areas. Nevertheless, sufficient movement information was collected to determine that post spawning grayling moved to the lower 28 mi of the Little Tok River, portions of which are accessible to anglers. It had been postulated that low tag recoveries by anglers of fish tagged at Mineral Lake Outlet indicated that the post spawning fish moved to inaccessible portions of the drainage (Fleming and Ridder 1991). These findings prove otherwise.

ACKNOWLEDGMENTS

The author thanks Bob Clark, Doug Edwards, and Danny Grangaard for their enthusiasm and persistence during field sampling; Don Roach, Matt Evenson, and Gary Pearse for their instructions and insights in fish surgery and radio tracking; Fronty Parker for his support of the project and assistance in aerial tracking; David Davenport for the processing of scale samples; Peggy Merritt for editing the report; and, Sara Case for final publication of this report. Also, thanks to Fred Anderson and Peggy Merritt for their administrative support and the extra three flights. Lastly, my greatest thanks to Paul Zaczkowski who took Fronty and I up and brought us down safely and never complained of flying in circles.

LITERATURE CITED

Beauchamp, D. A. 1990. Movements, Habitat Use, and Spawning Strategies of Arctic grayling in a Subalpine Lake Tributary. Northwest Science 64(4).

Clark, R. A. 1992. Age and size at maturity of Arctic grayling in selected waters of the Tanana Drainage. Alaska Department of Fish and Game, Fishery Data Series No. 92-5, Anchorage.

Clark, R. A. 1993. Interannual intrastream movements of Arctic grayling in the Chena, Salcha, and Goodpaster Rivers. Alaska Department of Fish and Game, Fishery Data Series No. 93-2, Anchorage.

Fleming, D. F. and W. P. Ridder. 1991. Stock assessment of Arctic grayling in Mineral Lake Outlet. Alaska Department of Fish and Game, Fishery Data Series No. 91-22, Anchorage.

Northcote, T. G. 1995. Comparative biology and management of Arctic and European grayling (Salmonidae, *Thymallus*). Review in Fish Biology and Fisheries, 5, 141-194.

Ridder, W. P. 1989. Age, length, sex, and abundance of Arctic grayling in Mineral Lake Outlet, 1969-1988. Alaska Department of Fish and Game, Fishery Data Series No. 87, Juneau.

Ridder, W. P. 1994. Arctic grayling investigations in the Tok River drainage during 1993. Alaska Department of Fish and Game, Fishery Data Series No. 94-19, Anchorage.

West, R. L., M. W. Smith, W. E. Barber, J. B. Reynolds, and H. Hop. 1992. Autumn Migration and Overwintering of Arctic grayling in the Coastal Streams of the Arctic National Wildlife Refuge, Alaska. Transactions of the American Fisheries Society 121:709-715.

Wojcik, F. J. 1955. Life history and management of the grayling in interior Alaska. Master's Thesis, University of Alaska, Fairbanks.

Yole, F. 1975. Methods of aging fish species common to rivers and lakes of the northern Yukon Territory, 1972-1974 *in* L. Steigenberger, M. Elson, P. Bruce, F. Yole editors. Northern Yukon Fisheries Studies 1971-1974. Volume 2. Prepared for Environmental Social Program, Northern Pipelines.

APPENDIX A

Appendix A.-Length, weight, age, and sex of grayling radio tagged in the lower 7 mi of the Little Tok River, fall 1994.

	Location (river mile)									
Date	Capture	Release	Frequency	ID# [a]	Length	WT (g)	Age	Sex	Tag#	Color
9/26/94	4	4	148.007	1	336	456	5	F	---	---
9/27/94	5-7	4	148.017	2	335	425	6	M	---	---
9/27/94	5-7	4	148.026	3	336	461	9	F	---	---
9/27/94	5-7	4	148.037	4	334	466	7	M	---	---
9/27/94	5-7	4	148.047	5	350	459	unk	M	---	---
9/27/94	5-7	4	148.057	6	328	409	5	F	---	---
9/27/94	5-7	4	148.067	7	319	367	5	M	---	---
9/27/94	5-7	4	148.076	8	333	398	4	M	---	---
9/28/94	2-4	2	148.087	9	350	482	6	M	---	---
9/28/94	2-4	2	148.097	10	353	478	8	M	---	---
9/28/94	2-4	2	148.107	11	349	452	7	M	---	---
9/28/94	2-4	2	148.117	12	337	397	6	M	13760	6
10/3/94	5-7	4	148.127	13	413	780	9	M	---	---
10/3/94	5-7	4	148.137	14	355	526	5	unk	---	---
10/3/94	5-7	4	148.147	15	352	561	8	unk	---	---
10/3/94	5-7	4	148.157	16	345	415	unk	M	---	---
9/27/94	5-7	4	148.167	17	357	518	7	M	---	---
9/27/94	5-7	4	148.177	18	359	535	7	M	27916	3
9/27/94	5-7	4	148.197	20	396	640	8	M	---	---
9/27/94	5-7	4	148.207	21	373	590	7	M	---	---
9/27/94	5-7	4	148.217	22	370	637	9	F	---	---
10/3/94	5-7	4	148.227	23	346	447	6	M	---	---
10/3/94	5-7	4	148.236	24	347	422	7	M	---	---
10/3/94	5-7	4	148.246	25	342	442	5	M	---	---
10/4/94	2-4	2	148.257	26	366	567	7	M	---	---

[a] The tag in fish 19 failed, thus an extra tag was inserted in fish 26; however the total number of fish in the study was 25.

unk = unknown

--- = not applicable

APPENDIX B

Appendix B.-Summary of angling location, effort, catch, and CPUE in the Little Tok River, 26 September through 4 October 1994.

Date	Location	#Anglers	Hours	Number Caught	Number Radio Tagged	AWL	Ang Hrs	CPUE
9/26/94	Broken Bridge	2	1.5	6	0	0	3	2.0
9/26/94	Glenn Bridge	2	1	3	1	1	2	1.5
9/27/94	Station Cr.	2	1.5	0	0	0	3	0.0
9/27/94	US Glenn Bridge	2	5	17	12	12	10	1.7
9/28/94	MLO	2	1	0	0	0	2	0.0
9/28/94	Broken Bridge	2	0.5	1	0	0	1	1.0
9/28/94	DS Glenn Bridge	2	3	8	4	4	6	1.3
10/3/94	MLO	2	0.5	0	0	0	1	0.0
10/3/94	US Glenn Bridge	3	4	16	7	16	12	1.3
10/4/94	DS Glenn Bridge	2	2.5	11	1	11	5	2.2
	Totals			62	25	44	45	1.4

APPENDIX C

Appendix C.-Water temperatures at selected sites in the Tok River drainage, September 1994 to May 1995.

Date	Little Tok River	Tok River	Mineral Lake Outlet	Tok Overflow	Station Creek
9/26/94	4.1	4.2	4.6	ND	ND
9/27/94	2.5	ND	ND	ND	2.2
9/28/94	1.2	0.6	2.5	2.5	ND
10/3/94	1.0	ND	1.8	ND	ND
10/4/94	2.0	3.8	ND	ND	ND
5/19/95	7.1	8.8	10.5	ND	9.5